



Educating the Next Generation of Scientists & Engineers for America

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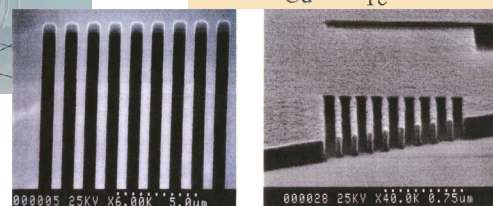
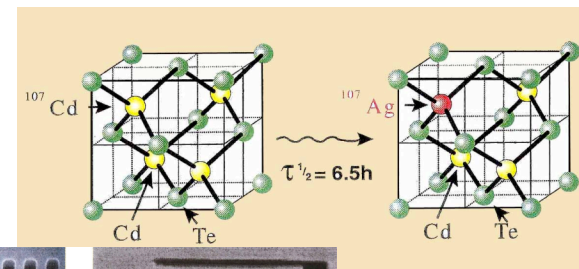
Dept. of Physics and Astronomy, UCLA



Motivations: Why does the Nation care? Why should students care?

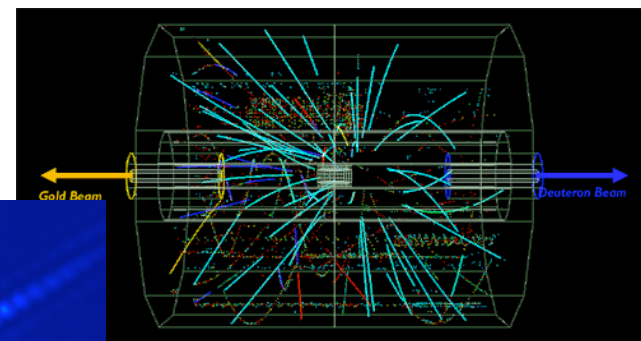
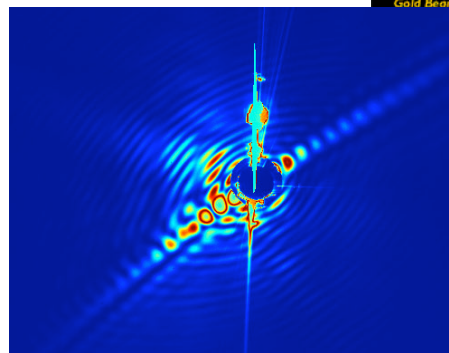


Medicine



Materials

Basic Research

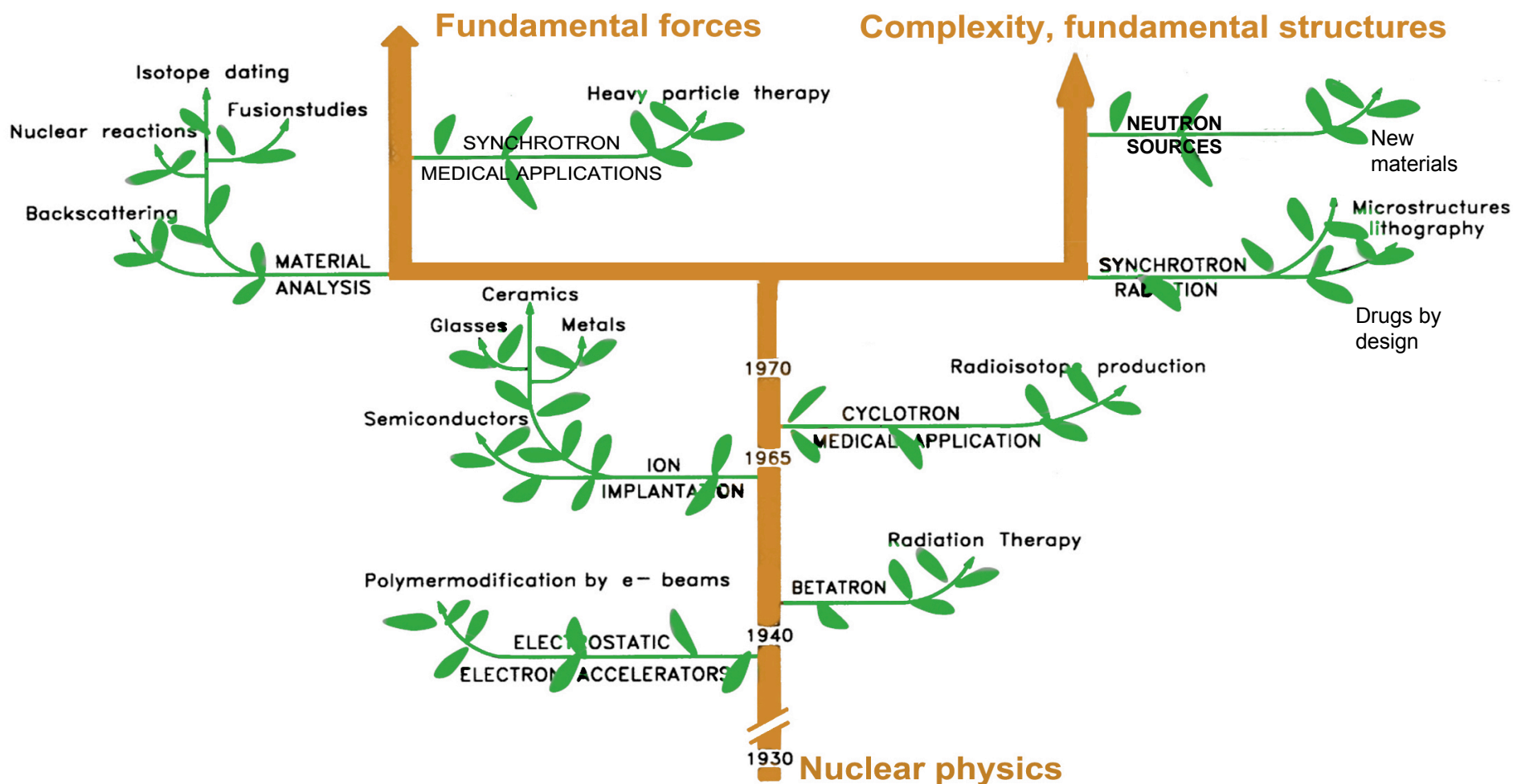


Brookhaven National Lab / RHIC-STAR Collaboration

*Exciting products...
exciting opportunities*



Accelerators are the hallmark of highly technological societies



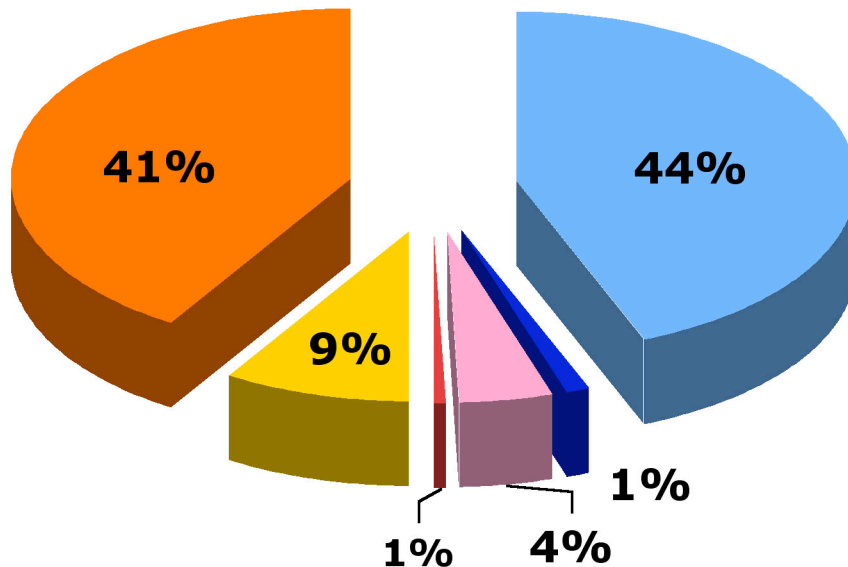
Societal applications & their technology develop from basic research



Accelerators are big business



**Number of accelerators worldwide
~ 26,000**



Radiotherapy (>100,000 treatments/yr)*

Medical Radioisotopes

Research (incl. biomedical)

>1 GeV for research

Industrial Processing and Research

Ion Implanters & Surface Modification

Annual growth is several percent

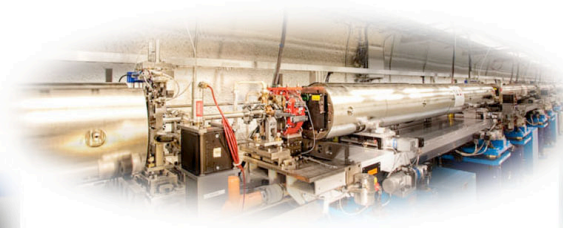
Sales >3.5 B\$/yr

Value of treated good > 50 B\$/yr **

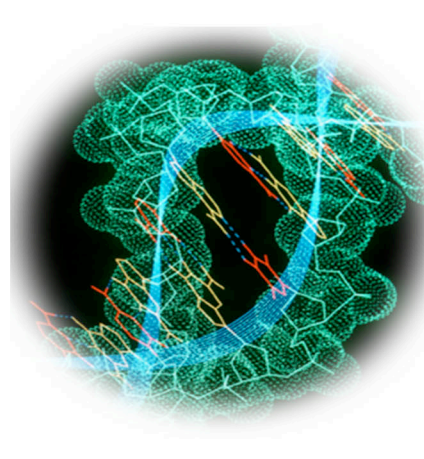
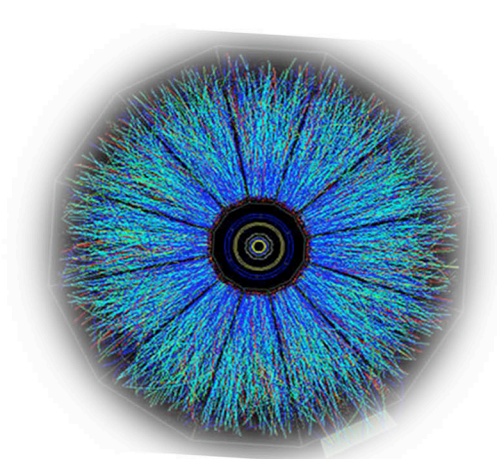
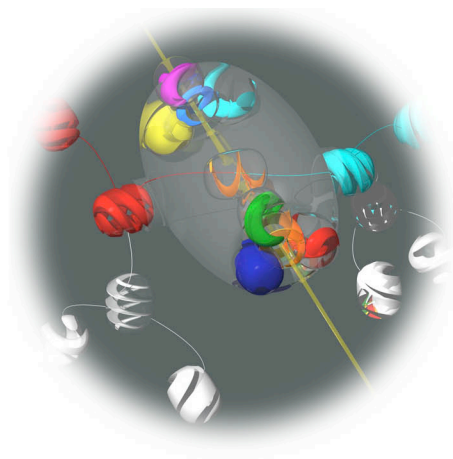
Major research machines are a tiny fraction of the total, but...



World-leading discovery science is America's competitive advantage



Accelerators are essential tools for discovery in physics, chemistry & biology





World-leading scientific education is also
America's competitive advantage



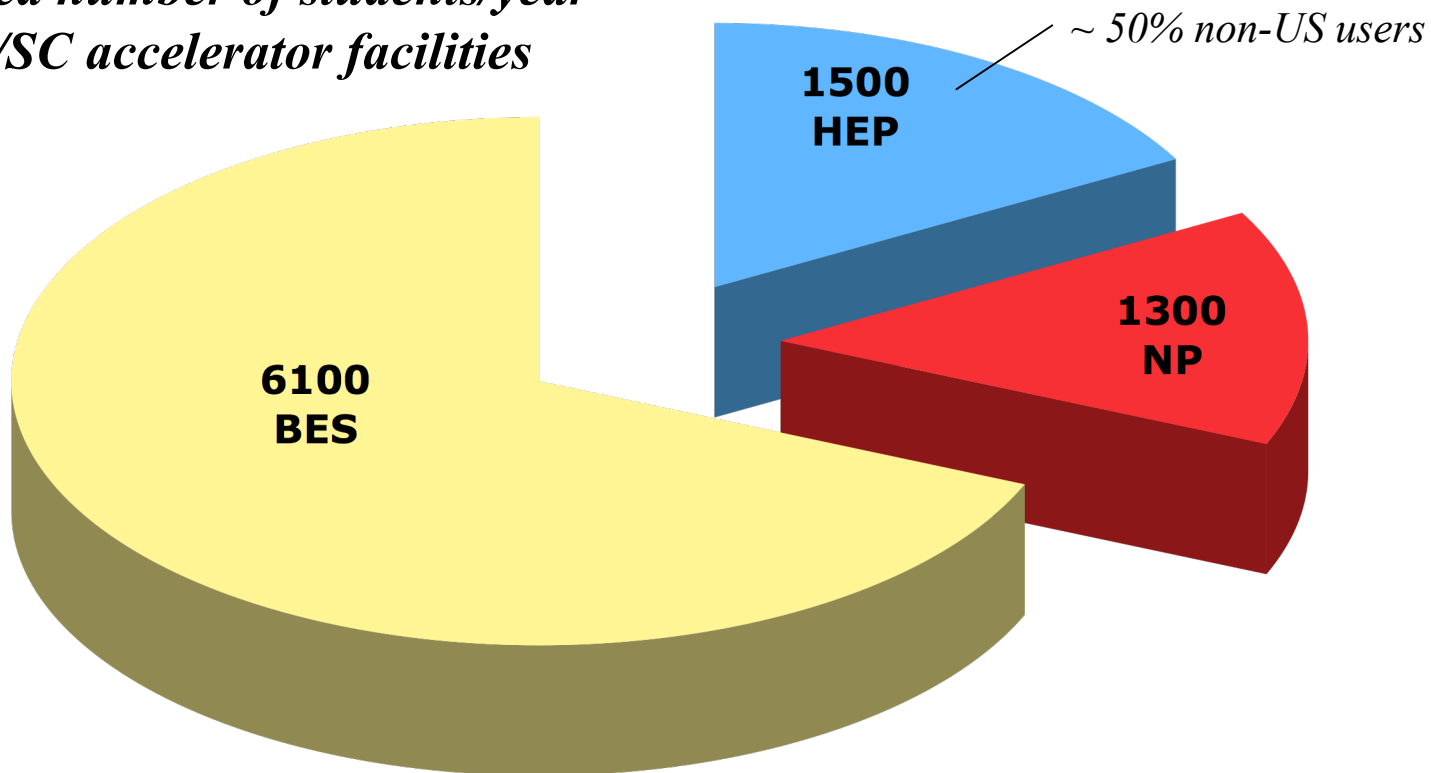
*We attract and train top talent from around the world
to attend US universities & use US scientific facilities*



DOE accelerators train future physicists, chemists & biologists for America



*Estimated number of students/year
at DOE/SC accelerator facilities*



~ 1400 PhD/yr in physics in US

Roughly 2/3 of facility users are students



Who pilots the machines?



- ✱ These machines are conceived of, design, built, operated & up-graded by a few hundred accelerator physicists
 - ➔ *A large fraction of these were trained outside the US*
- ✱ Many of my generation were HEP & NP experimentalists who learned about machines at accelerators on campus
 - ➔ *Very few of these now exist*
- ✱ Modern accelerators also require a much larger (2 - 3x) cadre of knowledgeable engineers
 - ➔ *Many critical courses are no longer offered in engineering departments*
 - *e.g., power electronics, microwave & rf-systems*



To summarize the problem



- ✱ Accelerators are essential tools for discovery science
- ✱ DOE spends almost 1 B\$ on major accelerator facilities
- ✱ > 26,000 accelerators in medicine, industry & national security constitute a multi-billion dollar/yr industry
- ✱ > 55,000 peer-reviewed papers having accelerator as a keyword are available on the Web

Yet...

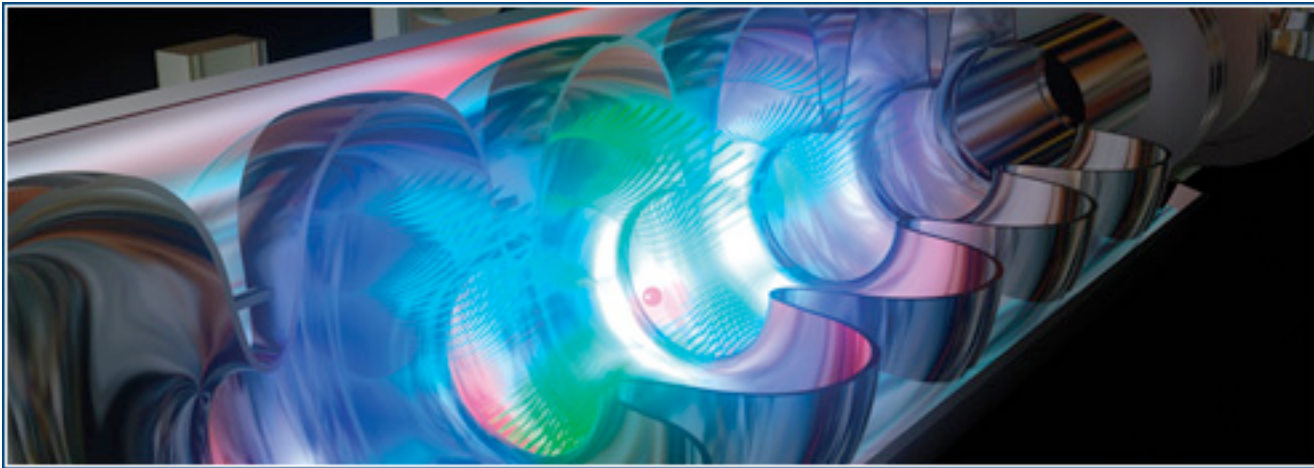
*Only a handful of universities offer any formal training
in accelerator science & technology*



Moreover, accelerators for future science...



- * ...Will be more challenging to design & build
- * ...Will be more challenging to operate



- * ...Will need outstanding physicists & engineers to realize
- * ... Will need experimentalists knowledgeable about accelerators to exploit fully



Reasons & excuses



✧ Structure:

- Accelerator science is inherently cross-disciplinary

✧ Prejudices:

- Physics departments, “accelerator science is ‘just technology’”
- EE departments prefer nano-technology & computing science

✧ Practicalities:

- It is difficult to enroll enough students for university approval
 - Even Cornell, UCLA, & Stanford can only offer core courses
- *Accelerator R&D at universities is insufficient to support strong faculty lines*



This serious challenge was recognized by
HEPAP sub-panels



- ✱ “The education & the training of the next generation of accelerator scientists & engineers is a *serious concern*.”
- ✱ “The *limited number of educational opportunities at universities is insufficient* to meet anticipated future needs.”

Advanced Accelerator R&D Sub-panel Report

- ✱ “The *present* University Grant Program level of effort shortfall is not consistent with US intentions to host the ILC.”

University Grant Program Sub-panel Report

The USPAS is dedicated to responding to this challenge



DOE & its laboratories must...



- ✱ ...Attract top undergraduate talent to graduate study of accelerator physics as well as accelerator-based science

*USPAS students won all top prizes
at PAC2009*



*Satomi Shiraishi
(Chicago)*

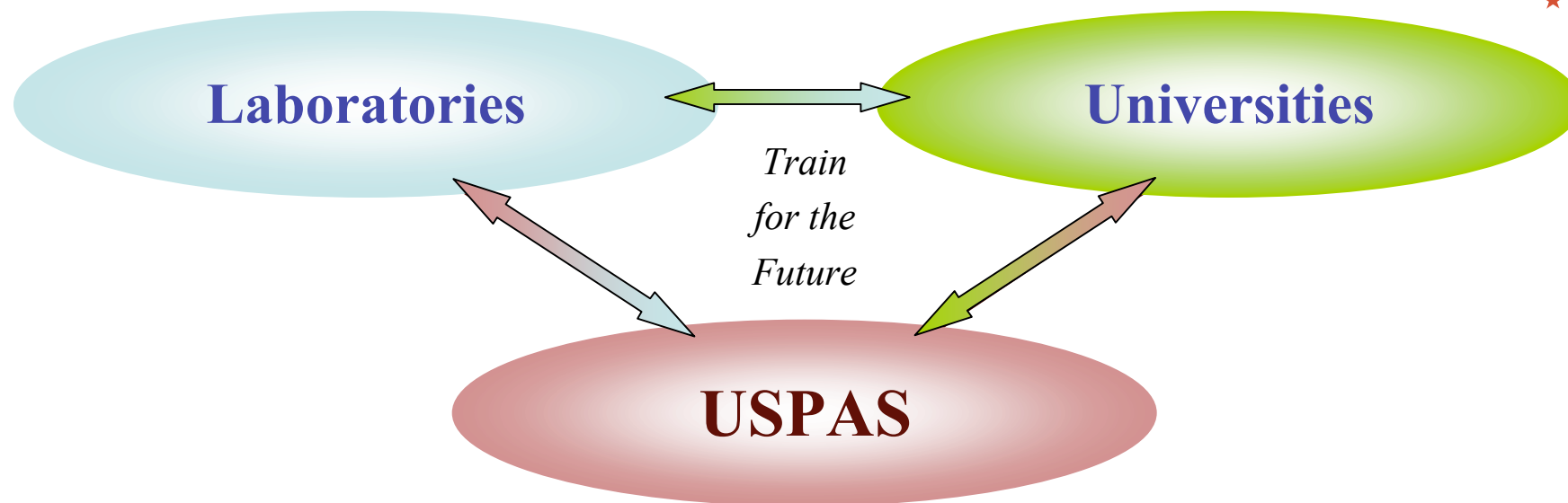
*Evelyn Meier
(Monash)*

*Anna Grasselino
(Penn)*

The USPAS is a central element in accelerator education in America



The USPAS Partnership Vision



The US Particle Accelerator School provides graduate-level educational programs in the science of beams and their associated accelerator technologies

We grant more academic credit in accelerator science & technology than any university in the world



Major US universities are our essential partners in education



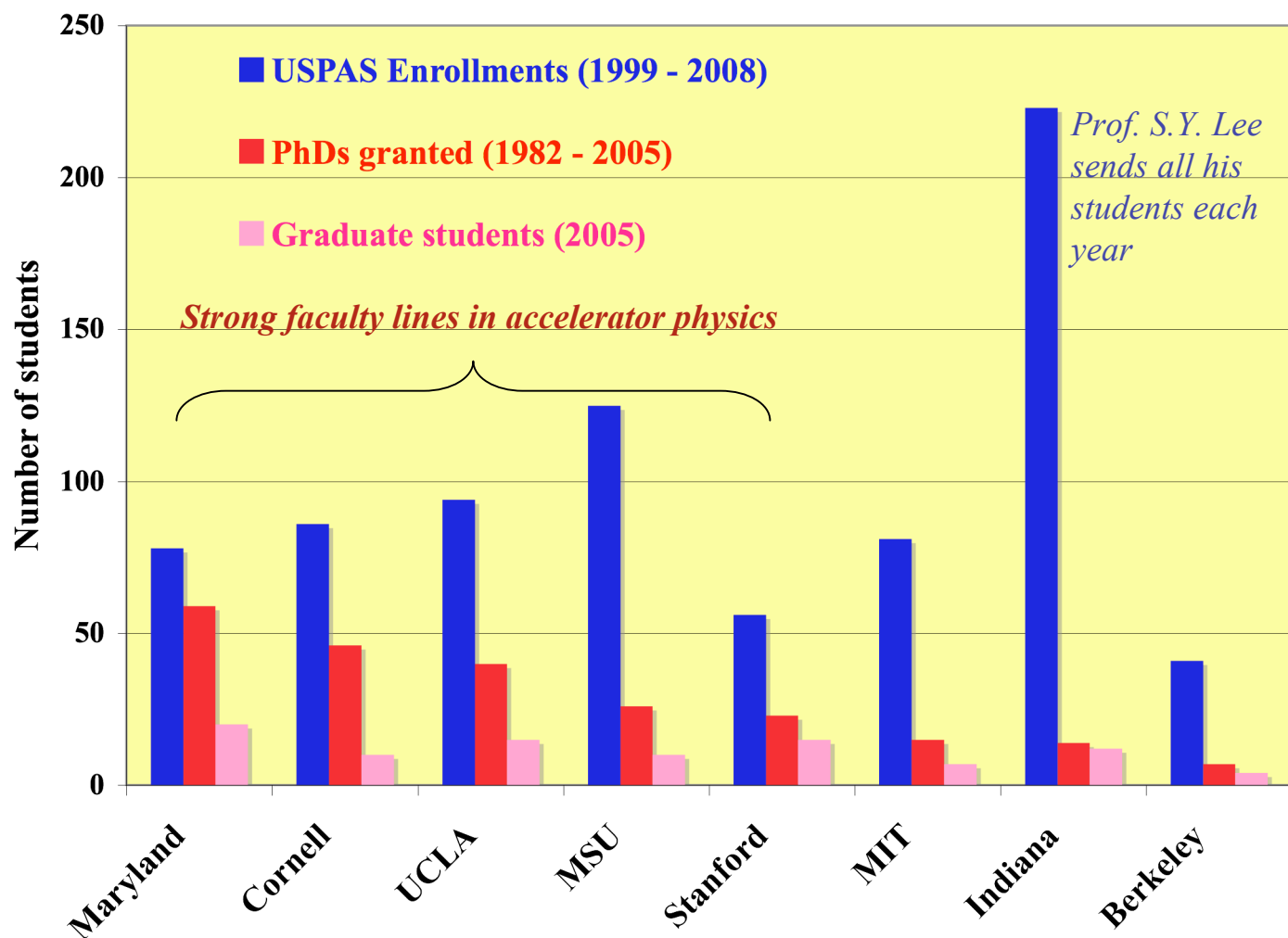
- ✱ Universities with strong graduate programs in accelerator physics provide a large student attendance at USPAS
 - ➔ Only Maryland, Cornell, MSU, UCLA, & Stanford have strong faculty lines (>2 professors)

Accelerator-based science needs several more such universities to assure an adequate, well trained professional workforce

- ✱ Universities with research accelerators
 - ➔ Emphasize innovation in accelerator science
 - ➔ Promote undergraduate awareness
 - MSU - 50 UGs annually; Cornell - 60 UGs annually
 - ➔ Offer exciting opportunities to engineering students
 - ➔ Encourage student experimentalists to learn about accelerators
 - ➔ Are a vanishing breed



Eight universities represent 80% of university attendees at USPAS ('99 - '08)



Of remaining PhDs granted (30%) many are from other lab-associated universities

US PARTICLE ACCELERATOR SCHOOL

Source: AARD 2005 Year Book, private communications (2008)



USPAS charter & financial model for educational stewardship



- ✱ Founded & nurtured under HEP auspices
- ✱ Letter from the four Energy Research AD's allows & encourages national laboratory sponsorship & support (1992)
 - ➔ Re-confirmed by DOE/SC & NSF in 2008
- ✱ Constituted as a partnership of sponsoring institutions
 - ➔ 7 SC laboratories (FNAL, ANL, BNL, JLAB, LBNL, ORNL, SLAC)
 - ➔ 2 NNSA laboratories (LANL, LLNL)
 - ➔ 2 NSF funded universities (Cornell, MSU)
 - ➔ 1 DHS office (DNDO/TARD)
- ✱ Partner institutions have funded all program costs
 - ➔ Partner support - 30 k\$/yr + faculty (only increased once in ~20 years)
- ✱ HEP funds USPAS Office at FNAL
 - ➔ Managing Institution



USPAS educational operations stress academic rigor



- ✱ 2 schools annually hosted by a major research university
 - ➔ 8 intense university, courses run in parallel (45 contact hours in 2 weeks)
 - ➔ Balance physics v. engineering, lectures v. hands-on
- ✱ Typical attendance per school ~ 130 students (recently ~150)
 - ➔ Scholarship support available for matriculated graduate students who take courses for credit
 - ➔ Credit-student workload during course > 8 hr/day
 - ➔ Graded homework & exams
- ✱ 40 university-style schools with >3100 individual students
 - ➔ Attended more than >1x / >2x / 3x >1030 / > 450 / >200
 - ➔ >200 have become intellectual leaders in their field
 - ➔ >25 USPAS graduate students have become USPAS instructors



We continually develop new offerings for our constituency

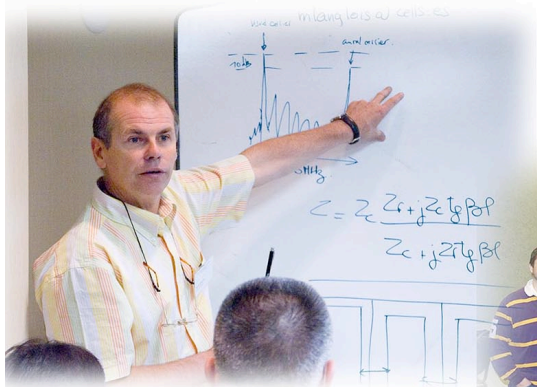
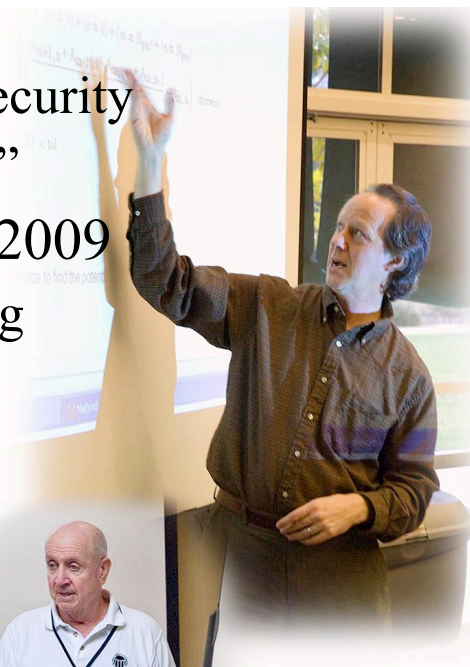


✧ New lecture courses in 2008

- Optics of High Energy Accelerators
- Radiation Imaging for Medicine & Homeland Security
- Special opportunity: “Vacuum Electron Devices”

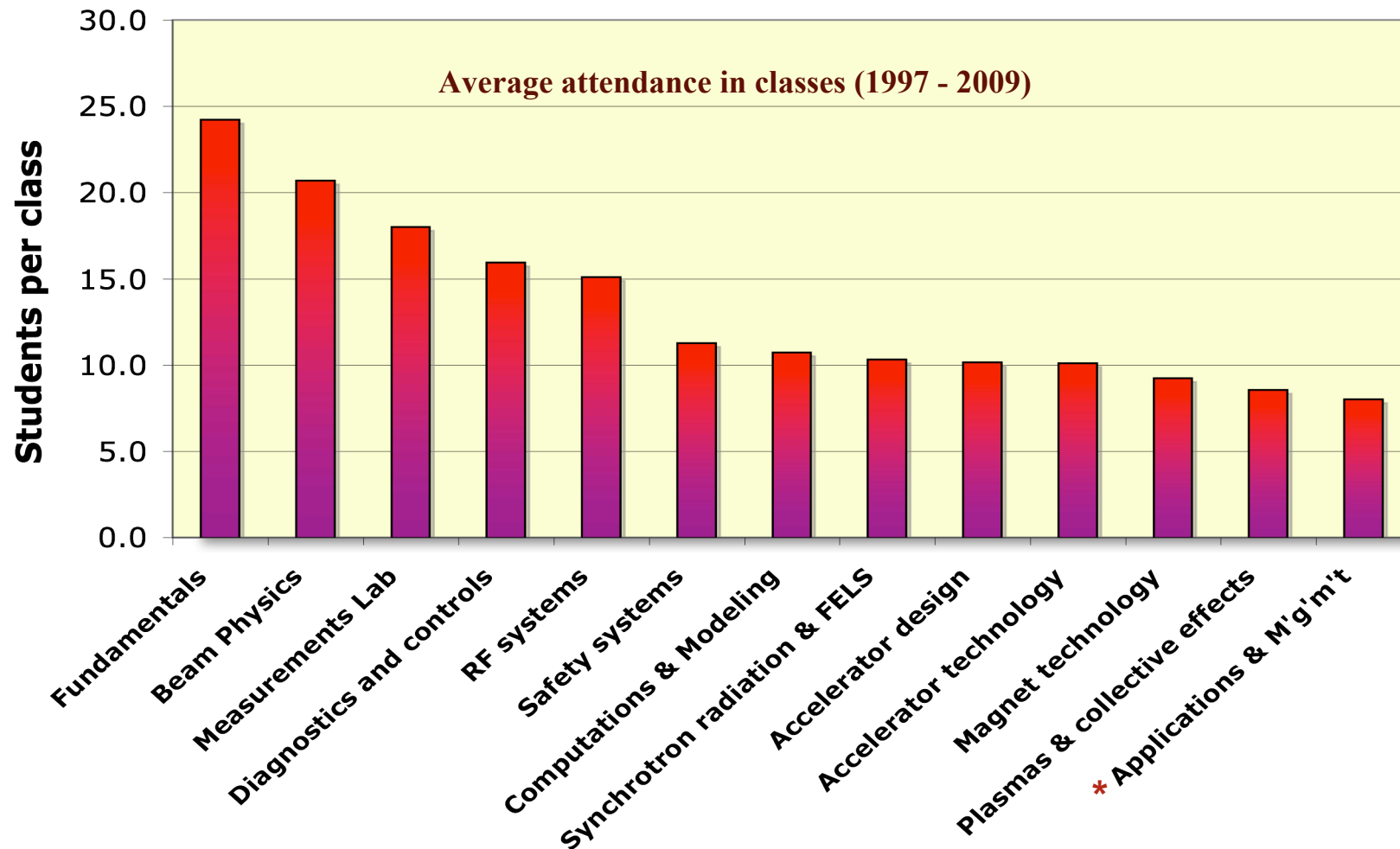
✧ 2 new, *hands-on* courses introduced in 2008 & 2009

- Synchronization, Timing & RF Signal Processing
- Synchrotron Light-based Beam Diagnostics
- Accelerator Diagnostics





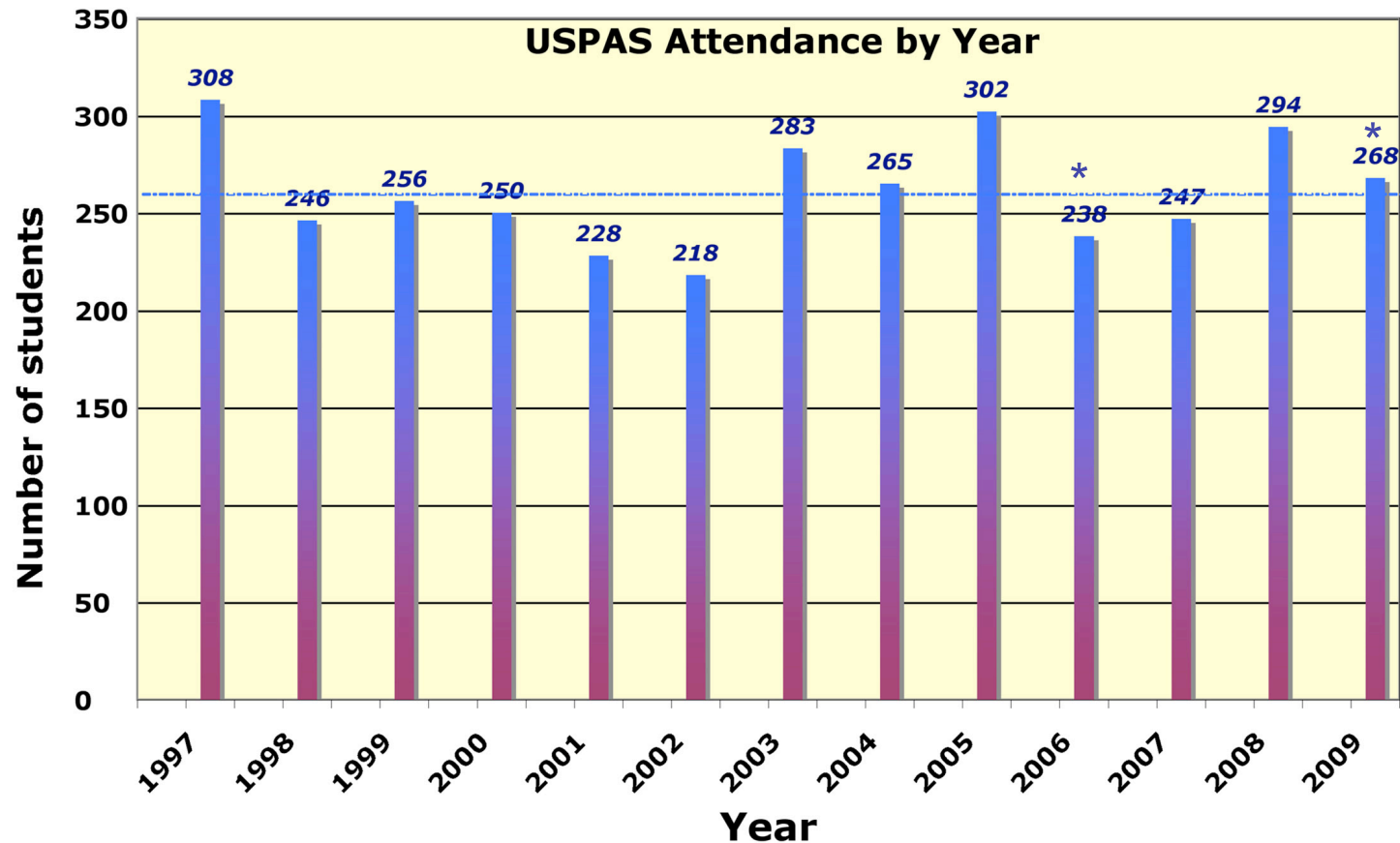
The strongest demand is for fundamentals



** In 2008 two medicine related courses had more than doubled to > 20 students*



We expect another session of ~150 students;
two-thirds receive financial support



* Years with visa issues; ~25% of attendees come from outside the US

*The present USPAS financial model cannot sustain
this level of student enrollment / support*



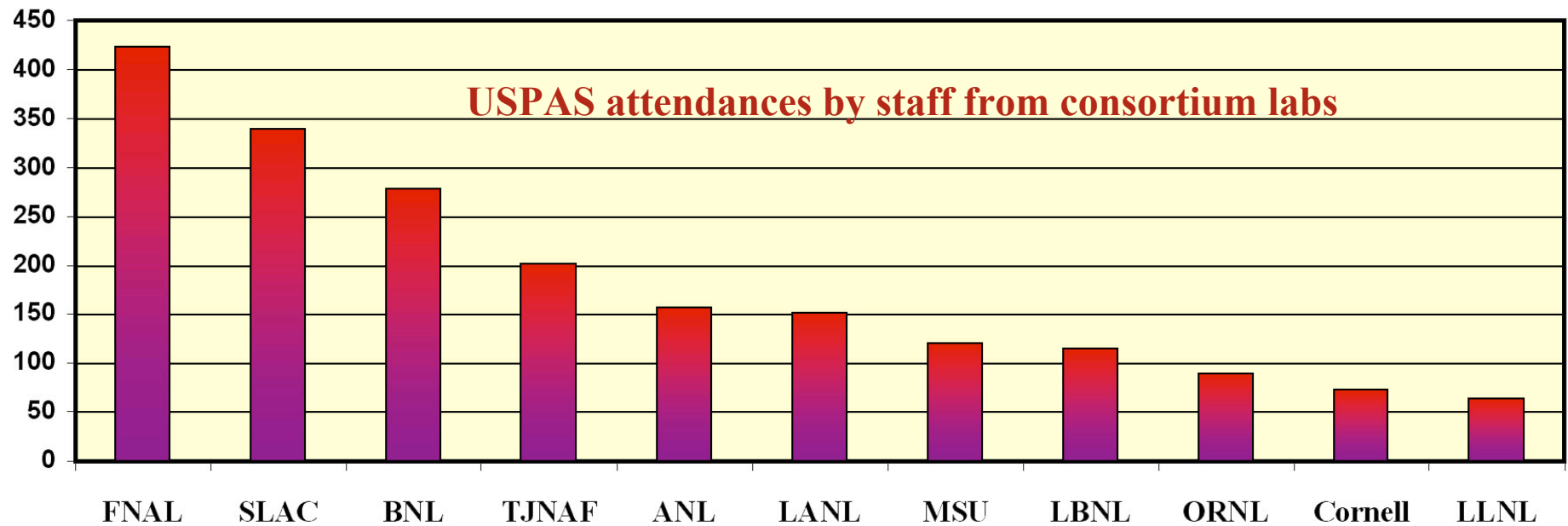
USPAS partners provide 2/3 of our faculty



We thank our instructors for their dedicated work



DOE labs have made excellent use of USPAS



*Normalizing MSU & Cornell by operating budget
==> interest level equivalent to Fermilab and SLAC*



Degree Programs & Academic Outreach



USPAS Degree Program



Master of Science
in
Beam Physics and Accelerator Technology
from
Indiana University & USPAS

7 degrees awarded

6 Students currently enrolled in program

Requirements: 30 Credit Hours: with grade point average of B or above

- * IU/USPAS Courses & Master's Thesis (3 - 9 credits)
- * Final Examination or oral defense of thesis

Nearly all are lab employees who get a promotion as a result



Undergraduate outreach: Teng Internship at Argonne & Fermilab



LEE TENG UNDERGRADUATE INTERNSHIP IN ACCELERATOR SCIENCE & ENGINEERING

The Lee Teng Internship is a highly competitive education and research opportunity, open to students from US universities who have just completed their junior year in physics or engineering. Teng scholars will receive a full scholarship to attend the US Particle Accelerator School Summer Session followed by an eight-week research internship at Fermilab or Argonne National Laboratory. Research projects will be of sufficient depth for a senior thesis. The internship offers full travel support and a generous stipend.

For further information and to apply see
www.leetengscholar.org

- * Engage highly promising post-junior undergrads to study accelerator science & technology
- * Encourage them to pursue graduate research & education in these fields
- * Interns study Fundamentals at USPAS
- * During remainder of summer, students undertake research project at the labs
- * ANL and FNAL selected 11 Teng interns in 2008 & 2009
- * We provide advice on graduate programs



Joint University-Fermilab Program: Accelerator Physics PhD



- ✱ Established in 1987
 - ➔ 1st graduate M. Syphers (UIC)
 - *Taught 11 USPAS courses*
- ✱ On average 5-8 students in the program simultaneously
 - ➔ 37 PhD graduates in 22 years
- ✱ Students apply & propose course of research
 - ➔ Admitted after passing university qualifying exams
 - ➔ Each has an University advisor & FNAL mentor
 - ➔ Research supported by FNAL



<http://phd.fnal.gov>



BNL & Stony Brook University: Center for Accelerator Science & Education



- ✱ Joint effort to nurture & grow existing efforts in accelerator science
 - ➔ BNL's RHIC, NSLS & ATF provide unique opportunities for cutting-edge graduate & undergraduate accelerator research
- ✱ The **CASE** Mission:
 - Pursue cutting edge accelerator R&D,
 - Train next generation accelerator scientists* - graduate & post doctoral
 - Attract undergraduate students to the graduate program* through introductory courses, laboratory work & summer internships at BNL
- ✱ Growth opportunities:
 - ➔ Expand successful Ph.D. and M.S. program
 - ➔ Attract the next generation students
 - Write & teach a curriculum for undergraduates
 - Sponsor a **Scholarship Program** to attract top **undergraduates to USPAS**
- ✱ Now operating from SBU seed grant & matching funds from BNL



**National Laboratory programs alone
will *not* provide
the accelerator professionals that America needs**

***Assuring the future vitality of accelerator-based
science & business
requires a new DOE investment in education***



Impediments we face...



- ✱ Undergraduates must be aware of the intellectual challenge & excitement of accelerator science
- ✱ Top undergraduates expect to study at a great university
- ✱ Students should spend a large fraction of time on campus
 - ➔ An education at a great lab is not an education at a great university

But, where?



How to begin...



- ✱ Some universities have occasional courses
 - ➔ Make them regular not just special topics
- ✱ DOE lab facilities offer thesis research opportunities
 - ➔ Augment with student support (tuition, assistantships, etc.)
- ✱ ANL & FNAL have Lee Teng accelerator internships
 - ➔ Other labs should follow suit
- ✱ USPAS offers the opportunity to co-list core courses

BUT, campuses need accelerator physics/engineering faculty

➔ Strong university-based research programs to support faculty lines



1) Expand university-based programs



- ✱ Vigorous, PI-driven program at universities allows growth of targeted, high priority R&D relevant to DOE/SC
 - ➔ Essential for innovations in accelerator science
 - ➔ Students can be trained & educated in accelerator science and technology in proximity to top experimentalists & theorists
- ✱ University programs can take a broad perspective with relation to exploratory accelerator science & technology
 - ➔ Offer broad intellectual resources both within physics and allied fields such as engineering, optical sciences, & materials sciences
 - ➔ Optimize incubation of new ideas & fundamental understanding
- ✱ Highly trained cadre of accelerator scientists will be essential to DOE/SC mission & national competitiveness



2) Assure USPAS financial stability



- ✱ Broad variety of USPAS offerings & *scholarship support* are crucial to existing programs in American universities
- ✱ USPAS provides an ideal attraction point & launching pad for undergraduates
- ✱ Maintaining the present level of enrollment & student support *requires* direct SC funding of USPAS sessions





Our students will be the future leaders
for our field...





... and not just leaders in accelerator physics



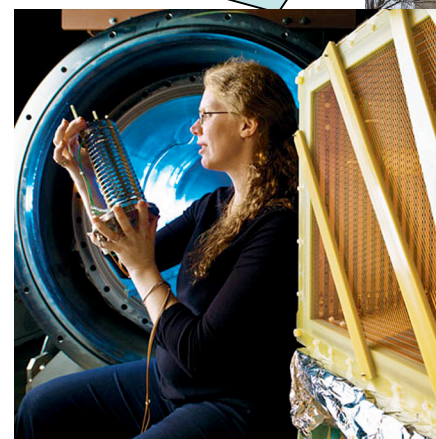
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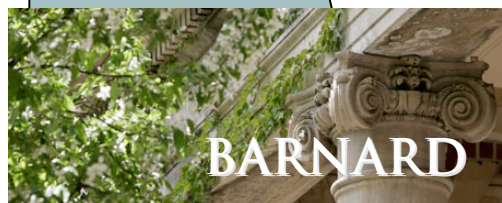
Physics
PhD



**Yale Professor
Bonnie Fleming**



**Spokesperson:
MicroBooNE
ArgoNeut**



B.A. Physics

*The time to invest is
now!*

Thank you



Schools across the Sea



CERN Accelerator School



- ✱ Training courses for accelerator physicists & engineers twice a year
 - ➔ Began in 1983
 - ➔ The courses take place in different member states of CERN
 - ➔ Consist of lectures & tutorials spread over a period of one or two weeks.
 - Participants from CERN member states & other countries world-wide
 - ➔ Director: Daniel Brandt

- ✱ Pattern of courses
 - ➔ Spring course on a specialist topic
 - ➔ Autumn course on accelerator physics
 - at the introductory level in even years
 - at the intermediate level in odd years
 - ➔ In even years an autumn course in the framework of the Joint Accelerator School (JAS) program
 - JAS is a collaboration between US, CERN, Russia and Asia

- ✱ Sessions lead to high quality, written proceedings
 - ➔ See <http://cas.web.cern.ch/cas/Proceedings.html>



The Joint Universities Accelerator School



- ✱ Intensive program for students & modular courses for professionals
- ✱ The full program covers many subjects during 10 weeks from January to March
 - ➔ Two five-week courses taught by Europe's accelerator specialists
 - ➔ Whole program includes about 180 hours of lectures, tutorials, guided studies & seminars
 - ➔ Lectures and tutorials are backed up by site visits / demonstrations
- ✱ Organized by European Scientific Institute
 - ➔ With support of CERN Accelerator School & several major European Universities
 - ➔ Examinations under the control of one of the partner universities validate the courses
 - Successful candidates may obtain credits at their home university through the European Credit Transfer System (ECTS)
 - It is recommended that all students take the examinations, which are *mandatory* for those students who receive a grant



We make different choices to serve different needs



	USPAS	CAS	JUAS	JIAS
Rigorous for-credit courses	Y	N	Y	N
Degree program available	Y	N	N	N
Frequent regular sessions	2/yr	2/yr	1/yr	N
Standing organization w. staff	Y	Y	Y	N
Duration (weeks)	2	1.5 -2	10	1.5 -2
On campus	N	N	N	N
Conference center/ hotel	Y	Y	Y	Y
Scholarships available	Y	Y	Y	Y
Specialty courses	Y	Y	Y	Y
Fundamental courses	Y	Y	Y	N
Hands-on courses	Y	N	N	N
Proceedings	N	Y	N	N
Lecture notes on web	Y	Y	N?	Y?

There are also specialty schools such as the recent Linear Collider Schools